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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/US90/02543 (22) International Filing Date: 4 May 1990 (04.05.90) (30) Priority data: 347,091 4 May 1989 (04.05.89) US (71) Applicant: EASTMAN KODAK COMPANY [US/US]; 343 State Street, Rochester, NY 14650 (US). (72) Inventors: OZIMEK, Edward, Joseph ; 52 Woodlyn Way, Penfield, NY 14526 (US). CARNALL, Edward, Jr. ; 22 Lynnhaven Court, Rochester, NY 14618 (US). (74) Agent: SCHAPER, Donald, D.; 343 State Street, Rochester, NY 14650 (US).		(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent). Published With international search report.	
(54) Title: METHOD OF MAKING A HERMETIC SEAL IN A SOLID-STATE DEVICE			
(57) Abstract <p>A method of making a hermetic seal for a solid-state device is disclosed. The device (10) includes a ceramic housing (12) having a cavity (15) for an element such as an image sensor (18). A cover (14) formed of a transparent material is sealed to the housing (12) to close the cavity (15). A metallization support (31, 41) is formed on the cover (14) and on the housing (12). In order to form a hermetic seal at a relative low temperature, a layer of indium (33, 43) is coated on the metallization support of either the cover (14) or the housing (12), and a layer (33, 43) of tin is coated on the support of the other of the two parts. The cover (14) is then placed on the housing (12), and the parts are placed in a furnace where a temperature under the melting temperature of the composite alloy of tin and indium is maintained for a period long enough to diffuse the tin and indium together. The temperature is then raised to a temperature sufficient to melt the alloy, and the device (10) is then slowly cooled to ambient temperature.</p>			

METHOD OF MAKING A HERMETIC SEAL  
IN A SOLID-STATE DEVICE

In the packaging of solid-state devices, a semiconductor chip is typically mounted within a cavity formed in a ceramic housing, and a cover is sealed to the housing to close the cavity. In U.S. Patent No. 4,750,665, there is disclosed a method of producing a semiconductor package in which a ceramic cover is joined to a ceramic housing using a gold-tin solder paste. When the solder has been applied and the cover and housing have been assembled together, they are heated to a temperature of about 350°C to form a bond between the parts. There is a problem in using such a process in the packaging of semiconductor devices which contain some types of image sensors. Certain image sensors include color filter arrays and lenslets which are formed of organic materials, and the temperatures used to melt the solder in the patented process can cause degradation of the organic materials.

Epoxy materials have been used to seal the packages of solid-state devices containing image sensors in order to avoid the high temperatures used in sealing semiconductor packages with solder. The epoxys, however, do not form a hermetic seal, and thus, they are not suitable for some applications. For example, solid-state devices used in military applications must meet the requirements set forth in a U.S. military specification, Mil-Std-883C, in which the packages must be able to withstand pressurized tests.

-3-

comprising: forming a metallization support on a housing; forming a metallization support on a cover for the housing; forming a layer of indium on one of the supports; forming a layer of tin on the other of the supports; positioning the cover and the housing such that the layers of indium and tin are in contact with each other; heating the cover and housing to a temperature of between about 70% and about 90% of the melting temperature of a composite alloy of tin and indium to diffuse the tin and indium together; heating the cover and housing to a temperature sufficient to melt the alloy after the diffusion is complete; and slowly cooling the cover and housing to ambient temperature.

15 In one embodiment of the present invention a method is disclosed for making a hermetic seal between a transparent cover made of a material such as quartz and a housing which is made of a ceramic material. The housing is adapted to receive an image sensor and to support the image sensor such that the sensor can be irradiated through the transparent cover. A metallization support is formed around the periphery of each of the parts to be joined. The top layer of the metallization support is a material such as gold which is formed over a base layer of nickel, titanium, tungsten, or chromium. The metallization supports are then cleaned, and at least one layer of indium or tin is plated on the clean surface of each of the supports. The top layer is indium for one of the parts, for example the cover, and the top layer is tin for the other part, ~~for example the housing.~~

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The cover and the housing are then positioned together and placed in a furnace. A very light pressure is applied, and diffusion of the materials is enhanced thermally by maintaining a temperature of approximately 80% of the melting temperature of a

-5-

housing 12 and are joined to an image sensor 18 which is contained within a cavity 15 in housing 12. Image sensor 18 can be of a type which includes a convex lens surface for each pixel, as disclosed, for example, in U.S. Patent No. 4,694,185, granted September 15, 1987. This patent is assigned to the assignee of the present invention.

Cover 14 is made of a transparent material such as glass, quartz, sapphire, or a transparent ceramic. A sealing pad 30 is formed on cover 14. Sealing pad 30 is formed from a plurality of layers, as shown in Fig. 4. The layers shown in Fig. 4 have been enlarged for purposes of illustration, and they are not shown to scale. Sealing pad 30 comprises a metallization support which consists of a layer 31 of nickel, chromium, or a titanium-tungsten alloy deposited on the cover 14, and a gold layer 32 which is coated over layer 31. Layer 31 is for bond enhancing or adhesion purposes, and the gold layer 32 is added to prevent oxidation. After the metallization support is formed, the surface thereof is cleaned using a plasma etch (500 watts r.f.; 300 mm oxygen; 30 minutes) or a u.v. ozone method can be used. After the cleaning step, a top layer 33 of either indium or tin is formed on the gold layer 32. Alternating layers of indium and tin (not shown) can also be used over the gold layer.

As shown in Fig. 2, a sealing pad 40 is formed on the housing 12. The sealing pad 40 includes a metallization support which is generally similar to the metallization support for pad 30 and consists of a base layer 41 (Fig. 4) of nickel, chromium, or tungsten, and a gold layer 42 deposited over the base layer. The support is then cleaned by a plasma etch as described above. A top layer 43 of indium or tin is then formed on the gold layer 42, or

-7-

housing, obtained from NTK Co., Springfield, New Jersey. A metallization support was formed on the housing which included a base layer of tungsten and a gold layer deposited on the tungsten. The  
5 tungsten layer was screen printed on the housing, and the gold layer was deposited on the tungsten using an electroless technique. The cover was a glass cover, obtained from Glass Specialty Company, Willow Grove, Pennsylvania. A metallization support was formed on  
10 the glass cover which included a base layer of a titanium-tungsten alloy containing about 10% titanium and about 90% tungsten and a gold layer deposited on the alloy. The titanium-tungsten alloy was deposited on the cover by vacuum deposition, and the gold layer  
15 was deposited on the alloy using an evaporation technique. The surfaces of the two metallization supports were cleaned chemically and etched in a plasma.

After the support surfaces were cleaned,  
20 alternating layers of In, Sn, In were deposited on the metallization support of the housing using a swab plating process, and alternating layers of Sn, In, and Sn were deposited on the cover metallization support using the swab plating process. The  
25 thickness of each of the metallization supports was about 0.005 mil. The thickness of each of the Sn and the In layers on the housing and the cover was measured using a Cyberscan 100 non-contacting optical  
30 profiler, and each of the layers was found to be about 0.1 mil. Thus, the total thickness of the  
~~sealing pad on the housing was about 0.35 mil. and~~  
the total thickness of the sealing pad on the cover was also about 0.35 mil.

The surfaces of the sealing pads were  
35 cleaned chemically by a freon TF (trichlorofluoroethane) solvent and by etching in a 50% hydrochloric

Claims:

1. A method of making a hermetic seal in a solid-state device, said method comprising the steps of:
  - 5 forming a metallization support on a housing;  
forming a metallization support on a cover for said housing;  
forming a layer of indium on one of said supports;
  - 10 forming a layer of tin on the other of said supports;  
positioning said cover and said housing such that said layers of indium and tin are in contact with each other;
  - 15 heating said cover and housing to a temperature of between about 70% and about 90% of the melting temperature of a composite alloy of tin and indium to diffuse said tin and indium together;  
heating said cover and housing to a
  - 20 temperature sufficient to melt said alloy after said diffusion is complete; and  
slowly cooling the cover and housing to ambient temperature.
2. A method, as defined in claim 1,
  - 25 wherein each of said supports includes a layer of nickel and a layer of gold thereon.
3. A method, as defined in claim 1,
  - ~~wherein said metallization supports are cleaned using~~
  - a plasma etch prior to being coated with a layer of
  - 30 indium or tin.
4. A method, as defined in claim 1,
  - wherein said melting temperature of the composite alloy is about 125° C.
5. A method, as defined in claim 5,
  - 35 wherein said cover and housing are heated to a temperature of 100°C to diffuse said tin and indium together.



1/2

FIG. 1

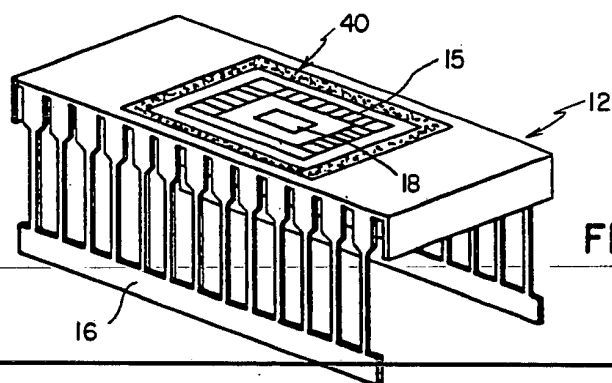
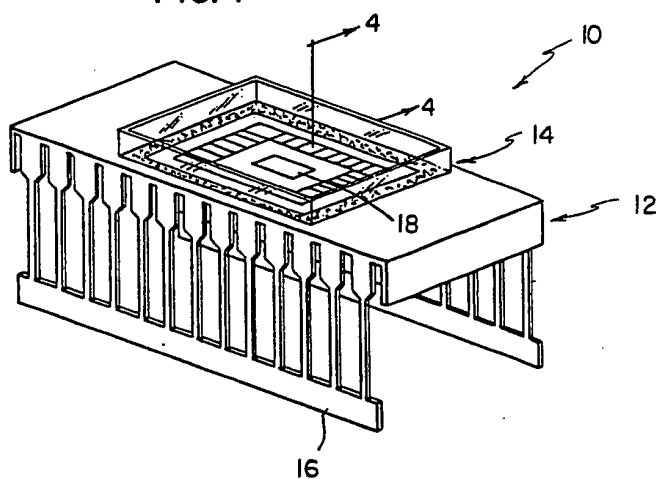


FIG. 2

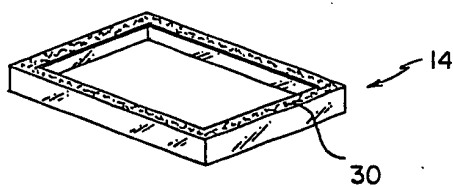


FIG. 3

# INTERNATIONAL SEARCH REPORT

International Application No PCT/US 90/02543

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) * According to International Patent Classification (IPC) or to both National Classification and IPC IPC <sup>5</sup> : H 01 L 23/10, H 01 L 21/50																										
<b>II. FIELDS SEARCHED</b> Minimum Documentation Searched † Classification System   Classification Symbols IPC <sup>5</sup>   H 01 L Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched ‡																										
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT</b> <table border="1"> <thead> <tr> <th>Category *</th> <th>Citation of Document, †† with indication, where appropriate, of the relevant passages ‡‡</th> <th>Relevant to Claim No. ‡‡</th> </tr> </thead> <tbody> <tr> <td>Y</td> <td>EP, A, 0089044 (NEC) 21 September 1983 see claims 1,3; page 7, lines 11-13, 21-24; page 9, lines 19-26; page 11, lines 5-14</td> <td>1</td> </tr> <tr> <td>A</td> <td>--</td> <td>2,4,6,7,9</td> </tr> <tr> <td>Y</td> <td>US, A, 3909917 (LEBEDEV et al.) 7 October 1975 see claim 1</td> <td>1</td> </tr> <tr> <td>A</td> <td>--</td> <td>1,2,4,5,6, 9</td> </tr> <tr> <td>A</td> <td>FR, A, 2183213 (PHILIPS) 14 December 1973 see claims 1,4,7,10,13,14</td> <td>3</td> </tr> <tr> <td>A</td> <td>US, A, 4159075 (SINGER) 26 June 1979 see claim 1</td> <td></td> </tr> <tr> <td></td> <td>./.</td> <td></td> </tr> </tbody> </table>			Category *	Citation of Document, †† with indication, where appropriate, of the relevant passages ‡‡	Relevant to Claim No. ‡‡	Y	EP, A, 0089044 (NEC) 21 September 1983 see claims 1,3; page 7, lines 11-13, 21-24; page 9, lines 19-26; page 11, lines 5-14	1	A	--	2,4,6,7,9	Y	US, A, 3909917 (LEBEDEV et al.) 7 October 1975 see claim 1	1	A	--	1,2,4,5,6, 9	A	FR, A, 2183213 (PHILIPS) 14 December 1973 see claims 1,4,7,10,13,14	3	A	US, A, 4159075 (SINGER) 26 June 1979 see claim 1			./.	
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* Special categories of cited documents: † "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "Δ" document member of the same patent family																										
<b>IV. CERTIFICATION</b> <table border="1"> <tr> <td>Date of the Actual Completion of the International Search 13th July 1990</td> <td>Date of Mailing of this International Search Report - 9. 09. 90</td> </tr> <tr> <td>International Searching Authority EUROPEAN PATENT OFFICE</td> <td>Signature of Authorized Officer H. Pez</td> </tr> </table>			Date of the Actual Completion of the International Search 13th July 1990	Date of Mailing of this International Search Report - 9. 09. 90	International Searching Authority EUROPEAN PATENT OFFICE	Signature of Authorized Officer H. Pez																				
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ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO.

US 9002543  
SA 36880

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.  
The members are as contained in the European Patent Office EDP file on 02/08/90  
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A- 0089044	21-09-83	JP-A- 58158950	21-09-83
US-A- 3909917	07-10-75	None	
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		NL-A- 7305890	06-11-73
US-A- 4159075	26-06-79	None	
GB-A- 1031436		None	
US-A- 4895291	23-01-90	None	

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